The Problem and a Trial Solution

Our introductory astronomy course at the University of Alabama has large enrollments necessitating multiple choice exams. There are the usual attendance problems with students putting off studying until just before major exams, with predictable consequences. This paper is an update of earlier research (Byrd, et. al. 2003, 2004) as well as its long-term effects in our department.

We (Byrd, faculty, assisted by Werneth, graduate student, and Coleman, undergraduate student) tried a strategy to actively involve students: cooperatively answering quizzes. We tried a “clinical trial” strategy to judge effectiveness, just change one thing between matched groups of subjects! There were the same teacher, similar students, the same content, mode of delivery, and same semester and time of day over three years.

The idea of eliciting understanding via a series of questions dates as far back as 400 BC by Socrates, as reported by Plato in the Meno dialog. We tried this solution during our
three week May 2002 Interim term. The Interim classes of three hours a day make mid-
class breaks essential. Before breaks, we presented a short multiple choice, open
book/note quiz answered after the break. The 2002 trial was decidedly “low tech” with
the students using “bubble” answer sheets. We wanted the daily quizzes to positively
motivate, increasing course grades without excessively diluting the importance of the
closed-book major exams. Correct answers to the quizzes could help the student’s final
course grade, counting up to 1/6 of the average. Wrong answers, however, did not hurt.
Perfect performance on daily quizzes could change a 70% course average to 75% with
smaller changes for higher averages. A course grade above 100% was not possible.
Missed questions on the regular closed-book, non-cooperative major exams did reduce
the students’ grades providing motivation to understand the daily quizzes. We
emphasized this to the students.

Exam Results and Student Opinions

Comparing the 2002 Interim closed-book non-cooperative final exams to Interim 2001,
the average was 80%, much better than the 2001 class’s 57%. There is very low
probability that this difference happened randomly. See Figure 1 for details. These final
exams were not handed back to the students so, we actually gave the same exams to both
groups. In our opinion, this procedure, along with the same interim term and no other
changes, improved the strength of our conclusions. Qualitatively, the 2002 students
appeared to interact with one another more in class than previously. Attendance was
over 90%. The 2002 cooperative quiz students did not do better because they had seen
typical multiple choice questions before the major exams while the previous class had not.
A sample set of multiple choice exams plus answers was handed out to the May 2001
students before each major exam.

We evaluated students’ opinions via our teacher/course evaluation. Students assigned a
grade for the course from A=5 to F=1. For 2001 Interim with no daily quizzes, the
average grade given the course was 3.80. For 2002 in which paper and pencil daily
quizzes were introduced, the average was 4.33, a statistically significant difference.
Students graded the daily quiz course as a better course! The grade given to the teacher
was statistically the same for both.
Need for Greater Convenience

During a regular semester, handing out and taking up papers would require much time during the more frequent and larger classes. Also, it is more interesting if the students vote for different answers together ("Is that your final answer.") then see the correct answer. To increase convenience, a grant was obtained to purchase a "Classroom Performance System" (CPS) from Einstruction Inc. The CPS consists of a computer receiver, software for creating quizzes, and 128 wireless response pads (which look much like TV remotes). Support for a University of Alabama Computer-Based Honors undergraduate (Coleman) also was obtained for assistance with software and entering questions and grades.

We used the system during Interim term 2003. Ease in giving quizzes and grading permitted more frequent and shorter quizzes. We gave a short 5 question quiz during the mid-class break with another at class end for a total of 27 quizzes (almost one per day for a regular semester’s Tuesday, Thursday class). Questions can be given during the lecture. The example introductory questions below are simple, but often such questions are missed even right after the material has been covered. The CPS quizzes enable the instructor to quickly identify and discuss misunderstood material.

1. If one goes outside on a bright, sunny day, how many planets can one be sure of seeing?

   A. 1  B. 9  C. 8, don’t be out of date!  D. None. It’s sunny, stupid!

2. Our solar system is composed of billions of
A. stars  B. planets  C. stars & planets  D. none of these (A,B,C)

We also used the CPS for introductory physics during summer 2003 as well as for astronomical events such as the recent Mars opposition. Kids of all ages like to check their understanding with a few questions. For physics, we have even written derivations as a series of multiple choice questions, similar to the Meno example, as part of a lecture. We also can do this in introductory astronomy, e.g., steps in obtaining distances of astronomical objects.

Classroom Performance System (CPS) Trial Results

Improvement was maintained with an increase from 80% to 83% for the CPS section. See Figure 1. Slightly more (7%) students stayed in the class rather than dropping out. The cooperative paper and pencil quizzes indicated improvement that was simply retained and made more convenient by the CPS. The average grade given for the CPS course was 4.19, still a statistically significant improvement over 3.80, and about the same as the paper and pencil section. Again, the students gave the teacher about the same evaluation “grade” as in the section with no daily quizzes.

Hardware and Cost

Initially, we attached the CPS pads to the classroom desks using metallic ball link pen chains common in banks. There was only minor attrition. We put hook velcro tabs at the top front for storage "in sight." Later, we found a rack at the classroom entrance works well. Our system used IR which has now been superseded by radio frequency (RF) units. Dr. J. W. Harrell in our department obtained RF sets that are stored in racks in our two Studio Physics classrooms. The cost to purchase a set is spread over many semesters so it is low per student per semester.

At the University of Alabama there is now a bookstore system treating the pads like resellable college texts. If one uses the bookstore option, the student must buy the unit, register it via the web, and re-sell it back to the bookstore. If the student uses the bookstore unit in several classes, the cost is reduced, but is probably higher than a classroom set. Casual conversations with students indicate they find the extra cost at the bookstore annoying plus they often forget to bring the unit to class that day of the week.

Classroom Operation

Casual use where the students' responses are strictly for diagnostic purposes, is easy to implement, since there is no assigned seating and the students get no credit for attending or answering. To give the individual students credit for answering questions, we assigned pad numbers to each student. With the rack system there were no problems with having to assign seating.
As a sensor gets data for each pad, its number lights up on the screen. Students are responsible for immediately reporting if their answers aren’t being recorded. With the RF units this is less of a problem than with the IR units.

We used a teacher-managed quiz mode in which the questions are answered sequentially together by all the students. In our experience, these should be short with no more than five questions to avoid tedium. The questions were available to the students for study outside of class afterward. There is a “grade book” in CPS software that can be used with the units. For our major closed-book exams, we used bubble scan sheets and randomized assigned seating to emphasize that these were “serious” and “different” from the in-class cooperative exams.

![AY101 Gains Without With Clickers](image)

**Figure 2.** Pre & Post tests % scores. Horizontal axis is individual Section Gain=Post %-Pre%. Time interval is 2008-2010. The vertical axis is 100%×(#Sections with Gains >Section Gain)/Total #Sec. There are 9 clicker, 8 no clicker sections. The vertical bars are median gains. Data courtesy Ray White, Physics and Astronomy Department, University of Alabama

**Clicker Use and Effectiveness in University of Alabama Astronomy Courses Today**

Our current department chair, Ray White, is enthusiastic about the use of clickers. The bookstore system is used. Somewhat more than half of the AY101 sections use clickers, mostly in those taught by our younger faculty members. The luxury of a multi-year matched “clinical trial”, however, is not possible. Faculty members who use the units
are compared to others who are non-users, and may be teaching at different times of the day or week. Use of the units, however, seems to result in improved gains over the semester on short tests at the end of the semester compared to pre-tests at the start of the semester. These tests are the same for all sections during a given semester. See Figure 2 for details.

**Conclusions**

We found that simple non-punitive cooperative quizzes are a successful strategy for teaching introductory astronomy. Our students not only learned more, but they liked the course more. The CPS system is not a panacea, but instead is a convenient way to implement the successful interactive, cooperative, daily quiz strategy. Its instant feedback enables the instructor to quickly identify facts or concepts which the students do not understand. Aside from its initial publication, this research has been included in two influential reviews (Duncan, 2006, Herreid, 2006) and a number of university teaching technology resource web sites. Long-term, clicker use is common in our department with indications that students learn more in the sections where this technology is used.

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